SKETCH OF THE GEOLOGY OF THE TORBANE MINERAL FIELD.

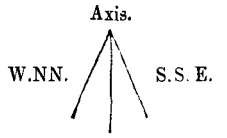
By Andrew Taylor, F.R.P.S., F.B.S.E.

The various corps of an army drawn up in line of battle are distinguished not only by their various uniforms, but also by the distinct position assigned them in the field. This greatly helps the general to the immediate disposition of sharpshooters, infantry, or artillery, as the fate of battle may require. Most of the minerals which are the basis of our commercial and mining greatness are obtained from the Carboniferous system. The industrialist obtains them from various parts of this formation. When a new substance has presented itself, having characters very different from the ordinary rank and file of coals, clay-bands, or fire-clays, its stratigraphical position will help us to determine if it is entitled to a distinct character. If its place be distinct from those of the ordinary coals, if likewise there are indications of a different physical mode of formation, then its claim to be a new mineral will be greatly strengthened.

The lower carboniferous rocks of Scotland consist of shales and sandstones more than a thousand feet thick, termed by Mr. Maclaren the calciferous sandstone series. A freshwater limestone, equivalent to that worked at Burdie House, near Edinburgh, is the predominant member of this group. This limestone runs in an elliptical area round that city for nearly twenty-four miles, extending through Fife, Midlothian, and Linlithgowshires. Part of this series extends to the south-east of the town of Bathgate, round which is the Torbane Hill mineral basin. A geological section in the Bathgate Hills, taken from Dechmont-law to Balbardie House, exhibits a limestone containing freshwater fossils, and equivalent to the one worked at Burdie House, gradually merged into another limestone containing marine fossils, which is usually recognized as the lowest bed of the carboniferous series.

The axis of the hills occurs in a wooded prominence overlooking the Caputhall Bogs, and near the "Clinking Stane." At this point the limestones may be traced within a few hundred yards of each other, dipping north-north-west and south-south-east. The Kirkton limestone, a peculiar bed, described by Dr. Hibbert, containing both marine and fluviatile remains, intervenes. Eastward from the prominence just indicated, both the axis of the hills, and the connexion of the limestones, may be traced in the burn running through Bangour Farm, at Binny, and thence at various points to the shore of the Forth at Hopetoun.

From the section described, the succession of the strata on either side of the axis, comprising the country eastward to Edinburgh on the one hand, and westward to Shotts on the other, is as follows:—



3. Upper Lanarkshire coal measures :— Wholly fluviatile organic characters.	3. Sandstones, shale, and a bed of coal.
2. Beds of marine and fluvio-marine limestone intercalated with shale, coal, ironstone, and stratified trap.	2. Freshwater limestone.
1. Shales, sandstones.	1. Shale, sandstone, tufa.

On the Bathgate Hills the marine limestone is sixty feet thick, and the fluviatile limestone about twenty feet thick. But towards the south-west, on the borders of Edinburgh and Lanarkshires, the marine limestone thins into beds of from three to six feet thick, whilst the freshwater bed is above fifty feet thick.

The Torbane Hill bed lies in number two of the left-hand series of strata. Along with two or three local coal-seams, it occupies a small mineral basin some two or three miles in area, lying immediately above the mountain-limestone, but stratigraphically distinct from the upper Lanarkshire coal-measures. The petrological structure of the surrounding strata is very unique; let us try to evolve their history.

The physical changes closing the life-era of the Scottish old red sandstone system are difficult to determine. From various geological reasons, the chief of which are the wave-ripples on the sandstones, and the physical structure of the surrounding mountain-chains, it has been deduced that central Scotland was a strait or frith bounded as now by the prominent peaks of the northern and southern Highlands. Islets, covered by a strange vegetation, dotted this watery expanse; from the eastward strong currents brought down the spoils of a now lost land, depositing the shales and sandstones so predominant round the Scottish metropolis. In this quarter, too, an intense volcanic activity prevailed.

The trappean bosses, which form so prominent a feature in the landscape round Edinburgh, were mostly erupted at this time. So, at least, the labours of Mr. Geikie and others go to prove.

From St. Abb's Head to Bathgate a chain of volcanos sent up their lurid contents into the Carboniferous sky. Nowhere was this activity more intense than on the Bathgate hills. The freshwater series to the eastwards of our section are everywhere intercalated with trap; some of it developed as aerial ash-beds, the rest as submarine greenstones. The prominences round Winchburgh, Binny, and Linlithgow, which the railway-traveller may remember so boldly characterize the scenery, are the memorials of these eruptions. The spot pointed out as the axis of the hills was undoubtedly the vent of a very active volcano. Immediately above Bathgate four or five great beds of basaltic greenstone and ash lie so intercalated with the aqueous strata as to

be only explicable on the hypothesis that they were emptied at the same time that the other strata were deposited.

The chemical changes effected by these igneous strata on the surrounding rocks are likewise very curious. In many places the limestone is changed into a crystalline marble. One bed at Kirkton affords undoubted evidence that it was deposited by a thermal spring. The great thickness the main bed of limestone in the hills attains, may be accounted for as much from its being a chemical deposit, as one of animal origin. The sandstones and shales, too, are often curiously baked, showing the violence of the igneous agencies. But we call special attention to the prevalence of bitumen in the district, sometimes appearing solid in the crevices of the sandstones, as at Binny; sometimes in round circular nodules in the trap or limestones; and sometimes oozing out liquid from trappean reservoirs.

The circular type of structure is very prevalent in the aqueous rocks of the district, as in the sandstone at King's Cavel, and amongst the ironstones. It extends throughout the rock systems. It is most manifest in the oolite or roe-stone of another formation. However we may explain it, it is clearly the result of agencies at work when the sandstones and shales were depositing, and not a subsequent chemical change. This admitted, it follows that most of the bitumen of the district is contemporaneous with the igneous rocks, and that the highly bituminous sandstones and shales were saturated at the period of their deposition. The clearest proof of this is the structure of the celebrated Binny sandstone. How else can we explain the black bituminous patches appearing on its surface? The physical agency at work may have been the conjunction of two rapid currents. But it is much easier to suppose the bitumen ejected from some neighbouring volcano floated in the waters of the lagoon or river in which the sandstone was forming, and then mechanically mingled with it; than that the sandstone was subsequently saturated from beneath.

Facts connected with the occurrence and formation of bitumen at the present day bear out this hypothesis. Its connection with volcanic agency is well known. The celebrated pitch-lake of Trinidad stands in close proximity to a volcano, as also do some of the bituminous localities in Asia Minor. All the three varieties of this substance float on water. Maltha, or mineral pitch, floats on the surface of the Dead Sea. Petroleum floats on the Tigris and Euphrates, so much so, that the surface of the river is often set on fire. The boatmen on the Tigris and Euphrates are paid in this substance. Doubtless at the bottom of these rivers there are many nascent beds of richly bituminous shales.

Given then a series of submarine volcanos ejecting out sheets of liquid bitumen, and at the same time sand and mud rapidly deposited; let these commingle, and we have the rationale of the formation of the Binny sandstone, and the bituminous shales of Queensferry and Broxburn. These forces ceased after a time. A morass was slowly formed which now constitutes the Houston coal-bed. This indicates

another condition under which bitumen was eliminated. In this case it is the result not of mechanical deposition, but of subsequent chemical action from decaying organic substances. Again, the action of the currents was resumed, and fresh bituminous shales were formed.

When the contemporaneous traps on the north-west side of our section were ejected, the same succession of physical changes continued. Bitumen occurs in globules both in the contemporaneous traps and in the limestones. The limestones indicate three marked alterations in the level of the land. First, the Kirkton limestone, with its leafy laminæ, and curiously baked beds of cherty porcelain, its interstratified ash, and over-capping basalt indicate proximate volcanic activity when forming. Fluvio-marine fossils are found in it. The land then sank so far as to allow the building corals to commence their labours; a reef was now formed which was added to by shells dashed in by the surf from the neighbouring sea, and the precipitation of carbonate of lime from a sea surcharged from its proximity to a volcanic cone; thus the great belt of the limestone of the hills was formed. But immediately after the land was subject to as rapid an elevation; as is manifest from the Stigmarias found in the upper bed of the limestone,—the lower beds abounding in deep-sea shells. Ash-beds also cover it. The hills now seem gradually to have risen above the waves, and a prevalence of freshwater strata filled the small Torbane Hill basin. But all this time the volcano did not stop its activity, as is evidenced by the thick ridges of interbedded basalt which may be traced terracing the country upwards from Bathgate. It is easy to suppose that sheets of bitumen, as at the prior period of the Binny sandstone, floated on the waters of this lagoon; that in one time in particular, a very large quantity was given out, and thus, aided mayhap by ejections from beneath, the Torbane Hill bed was formed. May not the round circular masses in the Torbane Hill mineral, which so puzzle microscopists, be the result of the action of currents,—only, however, on a smaller scale than those visible to the naked eye in the other rocks of the district? In suggesting this hypothesis we make allowance for the fact that at other times the basin was elevated so that morasses could accumulate, and thus the beds of coal be formed. The district thus exhibits evidence of both modes of the elimination of bitumen.

In the upland country west of the Torbane Hill basin there is a singular absence of trappean ridges. The district rises into a series of undulating hills formed solely of the upper members of the carboniferous system of Lanarkshire. The lower carboniferous volcano had ceased previous to their deposition; and the Bathgate hills probably formed elevated land at the base of the great strait in which these strata were depositing. Slowly the land rose and fell, morass after morass accumulated to be compressed into future coal-beds after being covered over by sand and mud. Bitumen was thus formed through chemical agencies. Its source is manifest from the microscopic structure of the coal, which is entirely of woody origin, not exhibiting traces of clay or sand from drift. The beds of this upper formation

were deposited over a wide area, and, unlike the Torbane Hill basin, with the greatest uniformity. This upper coal-basin then strikingly contrasts with the unique character of the Torbane Hill basin; and greatly aids our argument that the mineral was formed under different physical conditions from those of the true coal-beds.

NOTES ON THE METAMORPHOSIS OF ROCKS IN SOUTH AFRICA.

By Dr. R. N. Rubidge, of Port Elizabeth.

It is near eleven years since that in travelling through Howison's Poort,* one of the most picturesque of the many fine mountain passes through the quartzite ranges of the eastern province of the Cape Colony, my attention was drawn to a geological fact to which observation in other parts of the Colony has since led me to attach no little importance. In the construction of the main road from Port Elizabeth to Graham's Town, many deep cuttings have been made in the solid quartzite rock. In many instances the rock seen in these works lost its crystalline character gradually, and assumed that of a hard blue sandstone, and at length nearly resembled the blue fossiliferous shales and sandstones of the Ecca.

These quartzite rocks have been referred to the age of the Carboniferous formation of Europe by Mr. Bain (Geol. Trans. vol. vii. 2nd series, pp. 54 and 183), and both he and Dr. Atherstone ('Eastern Province Magazine,' vol. i. p. 588) describe them as conformable with the slaty rocks of the district. I have no doubt whatever that they generally are so. They pass gradually into each other, and, as I have described, the quartzite traced downward loses much of its siliceous character, and gradually assumes that of the slate and of the Ecca rock. This last is by Mr. Bain dissociated from the Carboniferous formation, and made the lowermost of the Lacustrine or Karoo series, but I have the following reasons for differing with him:—

1. At the western entrance of Howison's Poort are some beds of rock, intermediate in lithological character between the quartzite and the Ecca beds. These contain vegetable stems which have been recognized by many as identical with those of the Ecca. At Forester's Farm, east of Graham's Town, is a blue rock, just like that of the Ecca, containing the same fossils, which passes gradually into the gneiss. The sandstone on the one side is in relation on the other with the claystone-porphyry of Bain, as is the rock at the Ecca. Near Salem, in the heart of the Carboniferous system of Bain, are similar rocks with like fossils, conformable with the quartzite.

2. The strike of the inclined rocks, quartzites, slates, and Ecca rocks is throughout the province north 60° west nearly. If we draw

* Poort, a natural pass through a mountain range.